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Rediscovery and redescription of *Ixalus garo* Boulenger, 1919, and *Ixalus kempiae* Boulenger, 1919, with a reassessment of the taxonomic status of *Raorchestes cangyuanensis* Wu, Suwannapoom, Xu, Murphy & Che, 2019 and the description of a new species from the Garo Hills of Meghalaya

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Abstract

Bush frogs from Garo and Khasi Hills were collected, and a thorough examination based on morphology and geographic distribution revealed that two of the populations sampled from Garo Hills during this study agree with the holotypes and descriptions of the taxa *Ixalus garo* and *I. kempiae*, described more than a century ago. The original description lacked information on several morphological characters, genetic material, and photographs of the species in life. The absence of such information posed challenges in field identification of these species. Our phylogeny shows them to be nested within the *Raorchestes* clade, and therefore, we allocate these two species to this genus and formally announce their rediscovery. We also redescribe these two species here based on additional adult vouchers and report geographic range extensions from new localities. Based on molecular and morphological analysis, we reassess the status of the recently described *Raorchestes cangyuanensis*, resulting in its placement under the subjective junior synonymy of *R. kempiae*. We also describe a morphologically distinct new species from this region. This paper bridges an important gap in the knowledge of the genus *Raorchestes* in this part of India and highlights the importance of systematic surveys in documenting and understanding amphibian diversity in the region.

Key Words

cryptic diversity, Indo-Burma hotspot, IUCN red list, Rhacophoridae, synonymy, systematics

Introduction

The rhacophorid frog genus *Raorchestes* Biju, Shouche, Dubois, Dutta & Bossuyt, 2010 represents one of the most diverse vertebrate radiations in the Indian subcontinent (Vijayakumar et al. 2016). Though much of its diversity occurs in the Western Ghats of peninsular India (Vijayakumar et al. 2014; Priti et al. 2016; Garg et al. 2021), three species also occur in the eastern parts of peninsular India (Ganesh and Arumugam 2016; Gowande et

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al. 2020), extending further eastwards through Northeast India and Indochina (Wu et al. 2019; Al-Razi et al. 2020; Lalronunga et al. 2021; Huang et al. 2023). Most of these Southeast Asian species belong to the *Raorchestes parvulus* group (Vijayakumar et al. 2016; Garg et al. 2021). Boulenger (1919) described two species, *Ixalus garo* and *I. kempiae*, from 'above Tura' in the erstwhile Assam (now Meghalaya). Ahl (1931) transferred *I. garo* and *I. kempiae* to the genus *Rhacophorus* Kuhl & Van Hasselt, 1822, under the subgenus *Philautus* Gistel, 1848. They were then moved to the genus *Philautus* by Bourret (1942) (also see Bossuyt and Dubois 2001). Though there have been recent reports and descriptions of *Raorchestes* species from near the Northeast Indian region (Wu et al. 2019; Al-Razi et al. 2020; Lalronunga et al. 2021), these two species have never been documented. To this day, they remain poorly known to such an extent that even their generic assignment after the partition of *Philautus* remains unclear (see Frost 2024). We collected specimens of bush frogs from the Garo Hills, whose identities and affinities are examined in this paper.

Materials and methods

Field survey

Field surveys were conducted between October 2020 and January 2022 across 13 sites in the Garo and Khasi Hills of Northeast India. Nocturnal visual encounter surveys were carried out to locate calling individuals of bush frogs. Once located, the frogs were captured, photographed, and euthanized using benzocaine gel following protocols highlighted by Torreilles et al. (2009) and fixed in 90% ethanol after extraction of liver tissues, transferred to 75% ethanol for long-term storage, and deposited in the herpetological collection facility at SACON.

Species distribution mapping

The coordinates of each sighting of individuals encountered during this study were recorded using a hand-held GARMIN 64s GPS device (WGS 84 datum). The geographic range of the new species was estimated by plotting the known occurrences of the species from the current study on a distribution map generated using QGIS 3.24.1. The area under the minimum convex hull was computed by connecting the outer most occurrence points to calculate the Extent of Occurrence (EOO) as defined by the IUCN (2001).

Morphometrics

The following measurements were recorded to the nearest 0.02 mm from the specimens with an INSIZE dial caliper: snout–vent length (SVL, from the tip of the snout to the anterior margin of the cloaca), axilla–groin distance (AG, from the posterior margin of the forelimb at its insertion point on the body to the anterior margin of the hind limb at its insertion point on the body), head length (HL, from the posterior edge of the mandible to the tip of the snout), head width (HW, the maximum width of the head at the angle of the jaws), head depth (HD, the maximum depth of the head), body width (BW, the maximum width of the body at the trunk), eye diameter (ED, the greatest horizontal diameter of the orbit), eye–nostril distance (EN, from the anterior border of the orbit to the middle of the nostril), eye–snout distance (ES, from the anterior border of the orbit to the tip of the snout), tympanum diameter (TYD, greatest diameter of the tympanum), upper eyelid width (UEW, the maximum width of the upper eyelid), interorbital distance (IO, distance between the upper eyelids), internarial distance (IN, distance between the nostrils), upper arm length (UAL, from the axilla to elbow), lower arm length (LAL, from the posterior margin of the elbow to the base of the outer metacarpal tubercle), palm length (PAL, from the posterior border of the outer metacarpal tubercle to tip of the 3rd finger), femur length (FEL, from the cloaca to the knee), tibia length (TBL, from knee to heel), foot length (FOL, from inner metatarsal tubercle to the tip of the 4th toe). Webbing formulae follow Savage and Heyer (1997).

We compare the newly collected specimens from this study with the following congeners from the Indo-China region: *Raorchestes annandalii* (Boulenger, 1906); *Raorchestes yadongensis* Zhang, Shu, Liu, Dong & Guo, 2022; *Raorchestes shillongensis* (Pillai & Chanda, 1973); *Raorchestes rezakhani* Al-Razi, Maria & Muzaffar, 2020; *Raorchestes cangyuanensis* Wu, Suwannapoom, Xu, Murphy & Che, 2019; *Raorchestes longchuanensis* (Yang & Li, 1978); *Raorchestes dulongensis* Wu, Liu, Gao, Wang, Li, Zhou, Yuan & Che, 2021; *Raorchestes hillisi* Jiang Ren, Guo, Wang & Li, 2020; *Raorchestes parvulus* (Boulenger, 1893); *Raorchestes menglaensis* (Kou, 1990); *Raorchestes huanglianshan* Jiang, Wang, Ren & Li, 2020; *Raorchestes malipoensis* Huang, Liu, Du, Bernstein, Liu, Yang, Yu & Wu, 2023; *Raorchestes hekouensis* Du, Xu, Liu & Yu, 2024. Specimens of congeners were examined from museum collections when available and supplemented with additional morphological data from the following literature: Zhang et al. (2022); Boruah et al. (2018); Al-Razi et al. (2020); Wu et al. (2019); Jiang et al. 2020; Yu et al. 2019; Du et al. (2024).

Molecular methods

Total genomic DNA was extracted from three specimens of *Raorchestes* spp. (SACON VA 806, VA 809, VA 805) with a QIAGEN DNA extraction and purification kit, following the manufacturer's protocols. One mitochondrial 16s rRNA gene was amplified using the primers 16sAR-L (5'-CGCCTGTTTATCAAAAACAT-3') and 16sB R-H (5'-CCGGTCTGAACTCAGATCACGT-3'), respectively (Kocher et al. 1989). Amplifications were performed in an Applied Bio Systems Veriti 96-well thermal cycler: 20 µl reactions with 4 µl of 5X Phusion HF buffer, 0.4 µl of 10 mM dNTP, 0.2 µl of Phusion DNA Polymerase,

0.1 µl each of forward and reverse primers, 2.0 µl of DNA template, and 13.2 µl of nuclease-free water with the following procedure: initial denaturation of DNA at 95 °C for 5 min, 35 cycles of denaturation at 95 °C for 1 m, annealing at 55 °C for 1 min, extension at 72 °C for 1 m, and at last, final extension at 72 °C for 10 min. The amplicon was checked by running it through an agarose gel electrophoresis for a clear band of the desired region in the amplified PCR product. The amplified PCR product was purified and sequenced commercially. The forward and reverse sequences thus obtained were aligned along with seventeen other sequences of *Raorchestes* of the *R. bombayensis* and *R. parvulus* groups (*sensu* Vijayakumar et al. 2014), which were selected based on high similarity in the BLAST search, and two species each of the genera *Philautus* and *Pseudophilautus*, with *Nasutixalus jerdonii* as the outgroup taxon. The sequences were edited manually by deleting sites that corresponded to gaps, if any, and aligned with Muscle in MEGA 6.0 (Tamura et al. 2013). This alignment was exported in FASTA and MEGA formats and was then used to determine uncorrected pairwise genetic distances between the samples with MEGA 6. The alignment was then subjected to a maximum likelihood phylogenetic analysis with RAxML GUI 2.0 using the general time reversible model GTR GAMMA (as RAxML uses only the general time reversible (GTR) model of sequence evolution) with 500 bootstrap replicates. The tree file thus generated was then visualized using Fig Tree v. 1.4.0.

Results

Three distinct forms were identified based on morphological and molecular analysis. Our molecular as well as morphological analyses clearly revealed that the collected specimens belong to the genus *Raorchestes* (Fig. 1, Table 1), with one of the species (SACON VA 806) matching the morphological characteristics of *I. kempiae* while also being genetically close to *R. cangyuanensis* with high support (ML BS: 100) and low genetic divergence (0.46% on the 16S rRNA gene, which falls within the typical range of intraspecific divergence rates in members of this genus (Vijayakumar et al. 2014; Yu et al. 2019). The other population, SACON VA 809 from the high elevation zone of the Garo Hills (Sakalgre, ~1000 m asl.), was found to match the morphological characteristics of *I. garo*, and the molecular analysis showed that it was allied to *R. shillongensis* of the Khasi Hills, Meghalaya, albeit with a poor bootstrap support (51). The third identified entity (SACON VA 805), clustered together with two other samples of *Raorchestes* used in this study with a high bootstrap support (ML BS 100). The following section deals with the systematics of the identified entities.

Table 1. Uncorrected 16s pairwise genetic divergences between the Rhacophoridae species studied.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	14	15	16	17	18	19	20	21	22	23	24
1																											
2	9.19																										
3	6.00	7.31																									
4	0.69	9.47	6.25																								
5	0.69	9.47	6.25	0.00																							
6	5.80	8.15	5.01	6.06	6.06																						
7	6.04	5.78	4.28	6.30	6.30	5.05																					
8	9.19	0.23	7.56	9.47	9.47	8.15	5.78																				
9	9.19	0.23	7.56	9.47	9.47	8.15	5.78	0.00																			
10	7.06	5.79	6.75	7.32	7.32	6.81	4.51	5.79	5.79																		
11	6.53	5.77	5.02	6.79	6.79	6.55	4.50	5.77	5.77	5.21																	
12	6.05	5.28	5.52	6.31	6.31	5.06	3.06	5.28	5.28	3.76	4.24																
13	6.53	5.77	5.02	6.79	6.79	6.55	4.50	5.77	5.77	5.21	0.00	4.24															
14	6.51	6.23	6.23	6.77	6.77	6.51	4.23	6.23	6.23	4.74	4.71	3.75	4.71														
15	9.38	7.56	6.78	9.65	9.65	8.05	5.49	7.56	7.56	6.76	5.24	6.24	5.24	6.94													
16	7.06	6.05	6.00	7.33	7.33	6.05	4.02	6.05	6.05	5.50	5.00	4.03	5.00	3.99	6.73												
17	7.29	7.59	6.78	7.55	7.55	7.33	5.75	7.59	7.59	6.26	5.23	5.02	5.23	5.48	8.29	6.53											
18	9.07	6.50	6.26	9.34	9.34	7.78	4.74	6.50	6.50	7.22	5.48	4.97	5.48	5.67	4.00	5.70	6.50										
19	9.39	7.07	6.27	9.67	9.67	7.53	5.99	7.07	7.07	6.51	5.76	6.25	5.76	6.46	1.39	6.74	7.80	4.01									
20	10.8	7.86	8.34	11.0	11.0	10.2	7.53	7.86	7.86	7.25	6.71	7.75	6.71	7.25	10.4	7.51	9.09	9.29	9.87								
21	8.03	7.05	6.78	8.30	8.30	7.30	4.75	7.05	7.05	5.76	5.47	4.26	5.47	4.23	7.25	5.74	3.03	4.50	6.76	8.06							
22	9.45	0.46	7.81	9.73	9.73	8.41	6.03	0.23	0.23	6.04	6.02	5.52	6.02	6.47	7.81	6.29	7.84	6.75	7.32	8.12	7.30						
23	7.52	5.25	6.73	7.78	7.78	7.01	4.23	5.25	5.25	4.97	5.45	4.47	5.45	4.70	6.95	5.48	6.72	6.18	6.47	6.97	5.71	5.50					
24	13.2	14.7	12.7	13.2	13.2	12.1	11.5	14.7	14.7	13.1	11.7	11.0	11.7	11.5	11.6	11.5	11.0	11.5	12.8	14.5	10.9	15.0	13.3				
25	18.4	15.4	18.8	18.8	18.8	17.2	16.2	15.4	15.4	17.8	16.2	17.2	16.2	15.3	16.9	16.5	16.3	17.6	16.4	16.2	15.6	15.7	17.9	13.5			
26	13.2	13.2	12.3	13.5	13.5	14.0	12.5	13.2	13.2	13.1	12.0	12.6	12.0	11.4	14.5	12.5	12.0	13.3	14.2	14.7	13.6	12.9	11.9	14.8	20.4		
27	16.4	16.3	16.7	16.7	16.7	17.3	15.1	16.3	16.3	16.1	16.9	16.4	16.9	15.7	16.6	15.6	15.4	16.0	17.2	17.2	14.3	16.6	15.4	17.7	18.6	11.9	
28	18.9	17.9	16.7	19.3	19.3	18.6	15.7	17.9	17.9	16.3	17.5	16.2	17.5	19.0	18.2	16.8	18.4	18.4	18.8	16.2	17.1	18.2	17.1	18.3	20.0	16.1	16.7

1 = VA-805 *Raorchestes asakgrensis* sp. nov.; 2 = VA 806 *Raorchestes kempiae* comb nov.; 3 = VA 809 *Raorchestes garo* comb nov.; 4 = MN524577.1 *Raorchestes* sp.; 5 = JX092712.1 *Raorchestes* sp.; 6 = MG980283.1 *Raorchestes shillongensis*; 7 = MN475871.1 *Raorchestes longchuanensis*; 8 = MW98630.1 *Raorchestes longchuanensis*; 9 = MN193413.1 *Raorchestes longchuanensis*; 10 = MN072374.1 *Raorchestes rezakhani*; 11 = KF366385.1 *Raorchestes ghatei*; 12 = MN475869.1 *Raorchestes gryllus*; 13 = JX092687.1 *Raorchestes* sp.; 14 = MT488411.1 *Raorchestes hillisi*; 15 = MW019900.1 *Raorchestes menglaensis*; 16 = MW537816.1 *Raorchestes dulongensis*; 17 = KP137388.1 *Raorchestes tuberohumerus*; 18 = MW019901.1 *Raorchestes parvulus*; 19 = MT488414.1 *Raorchestes huanglianshan*; 20 = MG980285.1 *Raorchestes* sp.; 21 = MK188865.1 *Raorchestes sanctisilvaticus*; 22 = MN475866.1 *Raorchestes cangyuanensis*; 23 = MT983169.1 *Raorchestes annandalii*; 24 = MH789426.1 *Pseudophilautus schmarda*; 25 = KP939071.1 *Pseudophilautus kani*; 26 = MW356660.1 *Philautus nepenthophilus*; 27 = KT445970.1 *Philautus nephophilus*; 28 = KU170003.1 *Nasutixalus jerdonii*.

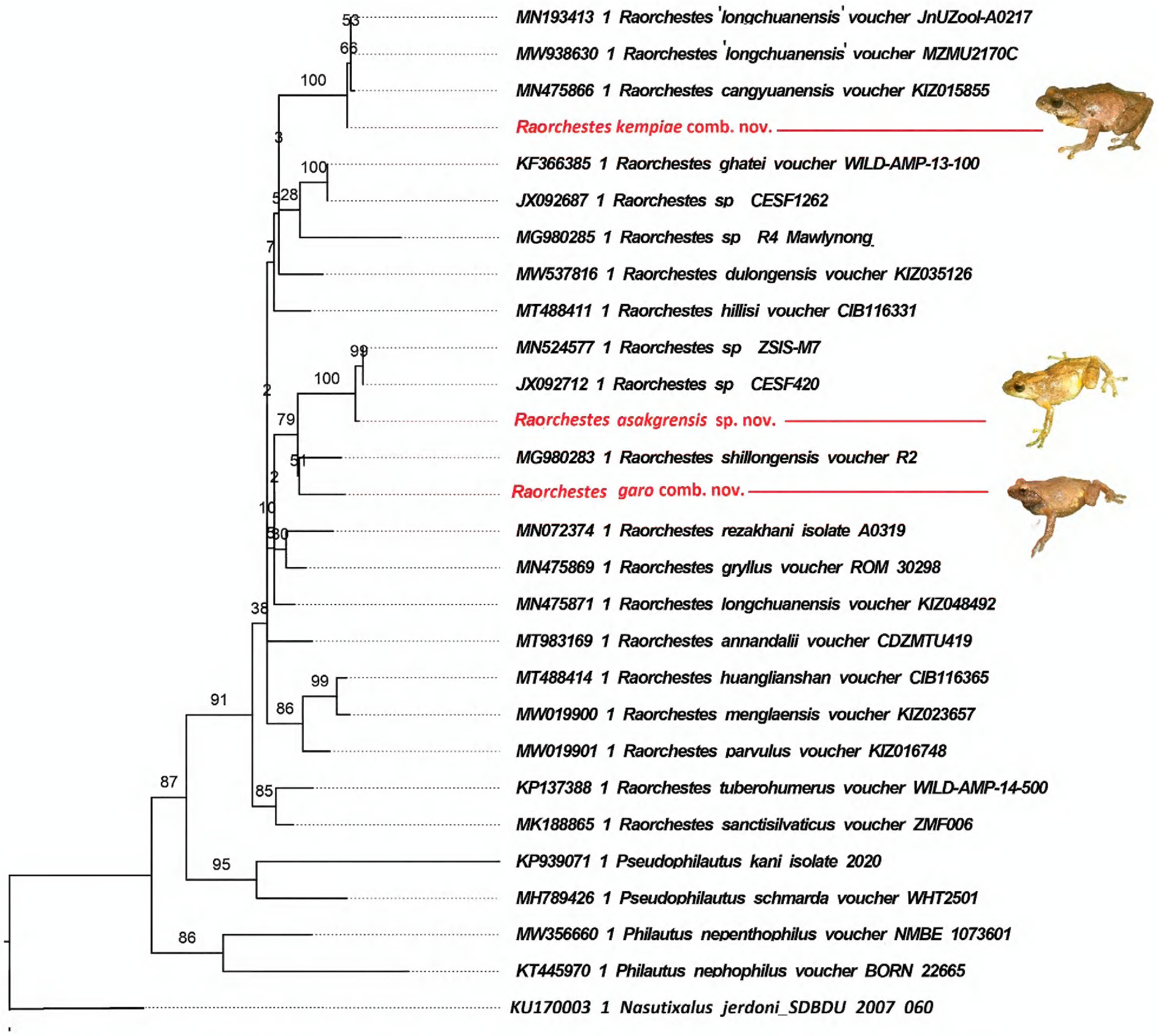
MN193413 1 Raorchestes 'longchuanensis' voucher JnUZool-A0217
MW938630 1 Raorchestes 'longchuanensis' voucher MZMU2170C
MN475866 1 Raorchestes cangyuanensis voucher KIZ015855
Raorchestes kempiae comb. nov.
KF366385 1 Raorchestes ghatei voucher WILD-AMP-13-100
JX092687 1 Raorchestes sp CESF1262
MG980285 1 Raorchestes sp R4 Mawlynong
MW537816 1 Raorchestes dulongensis voucher KIZ035126
MT488411 1 Raorchestes hillisi voucher CIB116331
MN524577 1 Raorchestes sp ZSIS-M7
JX092712 1 Raorchestes sp CESF420
Raorchestes asakgrensis sp. nov.
MG980283 1 Raorchestes shillongensis voucher R2
Raorchestes garo comb. nov.
MN072374 1 Raorchestes rezakhani isolate A0319
MN475869 1 Raorchestes gryllus voucher ROM 30298
MN475871 1 Raorchestes longchuanensis voucher KIZ048492
MT983169 1 Raorchestes annandalii voucher CDZMTU419
MT488414 1 Raorchestes huanglianshan voucher CIB116365
MW019900 1 Raorchestes menglaensis voucher KIZ023657
MW019901 1 Raorchestes parvulus voucher KIZ016748
KP137388 1 Raorchestes tuberohumerus voucher WILD-AMP-14-500
MK188865 1 Raorchestes sanctisilvaticus voucher ZMF006
KP939071 1 Pseudophilautus kani isolate 2020
MH789426 1 Pseudophilautus schmarda voucher WHT2501
MW356660 1 Philautus nepenthophilus voucher NMBE 1073601
KT445970 1 Philautus nephophilus voucher BORN 22665
KU170003 1 Nasutixalus jerdoni_SDBDU 2007 060

Figure 1. Maximum likelihood phylogenetic tree based on the 16S rRNA gene of select rhacophorid species, showing the phylogenetic positions of the *Raorchestes* spp. studied. Numbers on nodes represent bootstrap support values.

Systematics

Raorchestes garo (Boulenger, 1919), comb. nov.

Ixalus garo Boulenger 1919
Rhacophorus (*Philautus*) *garo* – Ahl 1931
Philautus garo – Bourret (1942)

Material studied. ***Holotype*:** ZSI 19187 (Fig. 2 above) sub adult, collected by S.W. Kemp, from "Above Tura".

Topotypes: SACON VA 809 (Fig. 2 below), 163, 305, 306, 308 adult males, collected by RSN on April 26th, 2022 from (25.51°N, 90.38°E, 895 m), and SACON VA 129, an adult female, on June 23rd, 2020 from Daribokgre Community Reserve (25.47297°N, 90.3148°E, 1200 m), East Garo Hills, Meghalaya, India.

Diagnosis. *Raorchestes garo* comb nov. is placed in the genus *Raorchestes* due to the combination of following characters: small body size, vomerine teeth absent, single translucent external subgular vocal sac present, and tips of all fingers and toes expanded into discs with circum-marginal grooves (see Biju et al. 2010). The species can be distinguished from congeners in the Indo-China region by the following combination of characters: A medium-sized (mean SVL 20.92 mm) arboreal species with a truncated snout scarcely projecting beyond the mandible; tympanum small, fairly distinct, ovoid, and supratympanic fold evident; tongue without papilla; ventral aspect of the hind limb dark orange in color; finger and toe discs well developed; tips of all fingers and toes brown to yellowish orange; toe webbing I1-1II1-1III3-3IV3-2.5V. Phylogenetically, *R. garo* clusters with *R. shillongensis* with a low bootstrap support (ML BS: 51) and shows the lowest genetic divergence from *R. longchuanensis* (4.28%).

Figure 2. The holotype of *Ixalus garo* (ZSI 19187) (above) (not to scale); SACON VA 809 in preservation (below); **A.** Dorsal view; and **B.** Ventral view. Scale bars: 10 mm.

Description of a topotype. SACON VA 809 Medium-sized adult male (SVL 23.8 mm), dorsal skin mostly smooth with a few irregularly scattered spinules and lateral skin completely smooth, ventral skin slightly granulose, increasingly granulose towards the lower body. Head large (HL:SVL 0.30), wider than long (HL:HW 0.86). A short snout (ED:ES 0.95), sharply pointed in dorsal view. Canthus rostralis evident and rounded; loreal region slightly concave. Trunk short (AG:SVL 0.54) and stout (AG:BW 1.20); eyes large (ED:HL 0.43); nostrils, rounded, with no visible rim, situated almost midway between the snout and the eye (EN:ES 0.58), directed laterally; with a weakly developed rim around them. Tympanum distinct, ovoid (TYD 1.36). Inter-orbital space broader than inter-narial space (IO:IN 1.59). Upper arms short (UAL:SVL 0.20), shorter than lower arms (UAL:LAL 0.75); palm shorter than the upper arms (UAL:PAL 0.74); relative finger lengths III>IV>II>I. Subarticular tubercles distinct in both palmar and plantar surfaces, rounded; no webbing between fingers; fingers with well-developed ovoid-shaped discs. Thighs short, nearly half as long as the body (FEL:SVL 0.46), nearly as long as the tibia (FEL:TBL 0.97). Foot slightly shorter than the thigh (FEL:FOL 1.29), toes short, toe discs well developed and ovoid, smaller than finger discs, toes with partial webbing, webbing formula I1-1II1-1III3-3IV3- 2.5V. Dorsum uniformly brown with yellowish white spinules; loreal region dark brown; iris golden brown. Venter white, speckled with black and gray spots, and lower trunk grayish brown. Groin orange (bordered by golden yellow) turning red as it reaches the thighs (Fig. 3).

Variation. Morphometric measurements of the holotypes and other preserved topotypes examined are presented in Table 2. Variations noted during examination of preserved specimens and live individuals observed in the field. The single female specimen collected during this study is larger (SVL 26.1 mm) than all the males (range 15.58–23.8 mm; mean SVL 20.92 mm). Dorsal coloration variable from light to reddish or dark brown. Some individuals with an hourglass pattern, intensity of the dorsal hourglass pattern variable from feeble to bold and black (usually absent in males during the breeding season). Some individuals with a darker hourglass pattern and light background (in VA 305), and some with lighter hourglass pattern and darker background (in VA 308). Bands on the limbs feeble to bold. Ventral coloration uniform in all individuals.

Comparisons. *Raorchestes garo* is genetically divergent (4.28–8.34% on the 16S rRNA gene) from congeners; the least divergent species is *R. longchuanensis*, with a divergence of 4.28%. However, on the phylogenetic tree, it clusters with *R. shillongensis*,

Figure 3. *Raorchestes garo* (dorsolateral view of SACON VA 809, on top and dorsal view of SACON VA 809, bottom left and dorsal view of VA 305, adult male bottom right, showing hourglass pattern) from Garo Hills in life.

Table 2. Morphometric measurements (in mm) of *Raorchestes garo* (abbreviations explained in Material and methods).

Voucher no:	Sex	SVL	AG	BW	HL	HW	HD	ED	EN	ES	TYD	ET	UEW	IO	IN	UAL	LAL	PAL	FEL	TBL	TRL	FOL
Holotype (ZSI 19187)	NA	12.6	5.82	5.3	2.62	5.92	3.5	2	1.2	2.4	0.3	0.4	0.72	1.7	1.32	2.62	2.74	3.45	7.26	7.24	3.74	4.52
SACON VA-809	M	23.8	12.92	10.8	7.18	8.34	4.36	3.12	1.92	3.3	1.36	0.7	2.28	3.56	2.24	4.66	6.2	6.32	10.98	11.34	7.3	8.54
SACON VA 163	M	21.38	9.72	8.02	7.22	8.24	4.26	3.04	2.12	3.46	1.44	0.3	1.68	3.08	2.3	4.28	6.1	5.38	9.82	11.1	6.36	7.24
SACON VA-305	M	22.16	11.4	10.54	7.76	8.5	4.98	3.1	1.4	3.58	1	0.32	1.76	2.76	2.06	4.62	5.44	6.54	10.34	11.36	6.8	9.06
SACON VA-306	M	15.58	7.8	7.02	4.7	5.2	3.92	2.3	1.3	2.34	0.82	0	1.42	2.06	1.5	2.8	3.68	3.5	7.2	7.96	4.42	5.46
SACON VA-308	M	21.66	10.98	8.4	6.6	7.8	3.98	2.94	1.4	3.06	1.4	0	1.68	2.76	2.24	3.44	5.3	6.1	9.8	10	5.5	7.26
SACON VA 129	F	26.1	13.2	11.9	8.62	8.46	4.9	3.5	1.6	4.02	1.7	0.86	2.46	4.8	2.48	4.32	5.02	5.8	11.84	12.42	7.12	8.58

with a low node support (51). From congeners in the Indo-China region, it can be easily distinguished by: having an externally visible tympanum (absent in *R. kempiae*, *R. shillongensis*, *R. menglaensis* and *R. rezakhani*); ventral aspect of the hind limb dark orange in color (vs. uniform creamy white in *R. kempiae* and dark gray in *R. rezakhani*); toe webbing I1-1II1-1III3-3IV3-2.5V in *R. garo* (vs. I1-2II2-1III1-1IV1-2V in *R. kempiae*, I 2–2 II 2–2 III 2–3 IV 3–2 V in *R. malipoensis*, II 1–2 III 1–2.5 IV 2.5–1 V in *R. menglaensis*, II 1–2 III 1–2.5 IV 2.5–1 V in *R. hillisi*, II 1–2 III 1–2 – IV 2–1 V in *R. huangliangshan* and I2–2 II 1.75–2 III 1.5–3 IV 2.75–2 V in *R. rezakhani*); snout short and truncate in *R. garo* (vs. rounded in *R. kempiae*, *R. menglaensis*, *R. hillisi*, *R. hekouensis*, *R. malipoensis*, *R. longchuanensis* and *R. huangliangshan* and sharply projecting in *R. annandalii* and *R. yadongensis*).

Natural history and distribution. These frogs can be heard calling at dusk. Males were seen to be actively vocalizing from April to September. Most individuals recorded during this study were observed to be calling from shrubs (usually higher > 2.5 m above the ground). The species was infrequently encountered and was only recorded from areas above 800 m asl during this study. This species was recorded from three different localities in and around the West Garo Hills region: Sakalgre (25.51°N, 90.38°E; 895 m); Daribokgre (25.47°N, 90.31°E; 1200 m); and Mandalgre (25.48°N, 90.41°E; 1081 m). Based on the locations from the study, we calculated the extent of occurrence of this species with the current data from this study, and it was estimated to be 11.46 km^2. However, further surveys are required to robustly estimate the distribution range of this species.

Remarks. Boulenger (1919) described this species from the Garo Hills along with *Bufoides kempi* and *R. kempiae*. Our topotypical specimens are in agreement with the holotype and with Boulenger's description in most characters. Kharkongor et al. (2016) reported a population of *Raorchestes* from Upper Shillong with detailed morphological description as *Philautus garo*. Although their descriptions of these specimens closely match the description of *R. garo*, since these are not topotypical populations, i.e., the collection locations occur almost 200 km (aerial distance) from the type locality and from a different elevational range, further studies based on molecular analysis are required to see if this population is conspecific with *Raorchestes garo*.

Raorchestes kempiae (Boulenger, 1919), comb. nov.

Ixalus kempiae Boulenger, 1919

Rhacophorus (*Philautus*) *kempiae* – Ahl, 1931

Philautus kempiae – Bourret (1942)

Raorchestes cangyuanensis – Wu, Suwannapoom, Xu, Murphy & Che, 2019, syn. nov.

Material studied. ***Holotype*:** ZSI 18859 (Fig. 4 above); sub adult, collected by Agnes Kemp, from "Above Tura".

***Topotypes*:** Five adult males, SACON VA 806 (Fig. 4 below), 301, 302, 297, 299 from Mikadogre Community Reserve (25.433660°N, 90.398981°E, 174 m), South Garo Hills, Meghalaya, India, collected by RSN on January 23rd 2021.

Diagnosis. *Raorchestes kempiae* comb nov. is placed in the genus *Raorchestes* due to the combination of following characters: small body size, vomerine teeth absent, single translucent external subgular vocal sac present, and tips of all fingers and toes expanded into discs with circum-marginal grooves (see Biju et al. 2010). The species can be distinguished from congeners in the Indo-China region by the following combination of characters: A small-sized (mean SVL 24.1 mm in adult males) arboreal species with a rounded snout; tympanum indistinct and supratympanic fold prominent; vomerine teeth absent; single semi-transparent gular vocal sac; tongue without papilla; ventral aspect of the hind limb and groin yellow with black or brown spots; finger and toe discs well developed; toe webbing I1-2II2-1III1-1IV1-2V.

Description (based on an adult male SACON VA 806). Small-sized frog (SVL 23.8 mm), with robust body. Dorsal skin mostly smooth with a few scattered spinules, ventral skin slightly granulose. Head broader than long (HL:HW 0.83); large (HL:SVL 0.33); with a short-rounded snout (ED:ES 0.72). Canthus rostralis evident and rounded; loreal region concave. Trunk short (AG:SVL 0.41) and stout (AG:BW 1.02); eyes large (ED:HL 0.38); nostrils, ovoid, with no visible rim, situated closer to the snout tip than to the eyes (EN:ES 0.61), directed laterally. Inter-orbital space broader than inter-narial space (IO:IN 0.69). Tympanum indistinct. Upper arms short (UAL:SVL 0.28), shorter than lower arms (UAL:LAL 0.57); palm slightly shorter than the upper arms (UAL:PAL 0.54); relative finger lengths III>IV>II>I; Subarticular tubercles distinct in both palmar and plantar surfaces, rounded; Supernumerary tubercles present in the palm; no webbing between fingers; fingers with well-developed rounded discs. Thighs short, nearly half as long as the body (FEL:SVL 0.32), slightly shorter than the tibia (FEL:TBL 0.83). Foot shorter than the thigh (FEL:FOL 2.83), toes short with well-developed rounded discs, partial webbing, webbing formula I1-2II2-1III1-1IV1-2V. Dorsum uniformly brown with a faint hourglass pattern. Loreals pale brown, iris dark golden brown. Venter granular, pale gray, spotted with gray and brown in lower trunk and thighs. Lateral aspect of the hind limb and groin orangish yellow with black and brown blotches (Fig. 5).

Variation. Morphometric measurements of the holotypes and other preserved topotypes examined are presented in Table 3. Variations noted during examination of preserved specimens and live individuals observed in the field. Dorsal coloration ranging from light brown to brownish black with or without an ")(" pattern (present in VA 301 and VA 302). Brown or black stripes over the thighs and tibia. Some individuals have a bright yellow to white band across the interorbital region (Fig. 5).

Natural history and distribution. Males were usually observed to start calling at dusk from bamboo bushes. The species was recorded from Mikadogre Community Reserve (25.434°N, 90.399°E, 174 m) and Bollonggre village (25.489°N, 89.995°E, 150 m) from South Garo Hills and Nengmandalgre Fish Sanctuary (25.494°N, 90.548°E, 410 m) from East Garo Hills. Based on these locations and the locality provided by Wu et al. (2019), we estimated the extent of occurrence of this species to be 242,491 km². We observed it to be relatively abundant across an elevational gradient of 100 m asl to 1200 m asl. Therefore, we recommend that this species be downgraded from Critically Endangered to the least concern category.

Remarks. Wu et al. (2019) described *Raorchestes cangyuanensis* from Yunnan Province, China. However, they did not compare this species with the senior taxon *Ixalus kempiae*, likely because *I. kempiae* had remained poorly known since its description and there had been no literature available on this species based on new sightings since it was first described. It is also unusual for frogs of the genus *Raorchestes* to have such wide distribution ranges (see Vijayakumar et al. 2014). We conclude that *Raorchestes cangyuanensis* is a junior synonym of *Raorchestes kempiae* based on molecular and morphological evidence (see Tables 1, 3). In addition to this, Gouda et al. (2023) regarded *Raorchestes cangyuanensis* as a subjective junior synonym of *R. manipurensis* (Mathew & Sen, 2009). Our analysis also revealed that specimens referable to both these names actually show characters that are diagnostic of *Raorchestes kempiae* (Boulenger 1919), a species described much earlier but overlooked until now due to improper and deficient comparisons. However, since we did not have molecular data or access to type specimens of

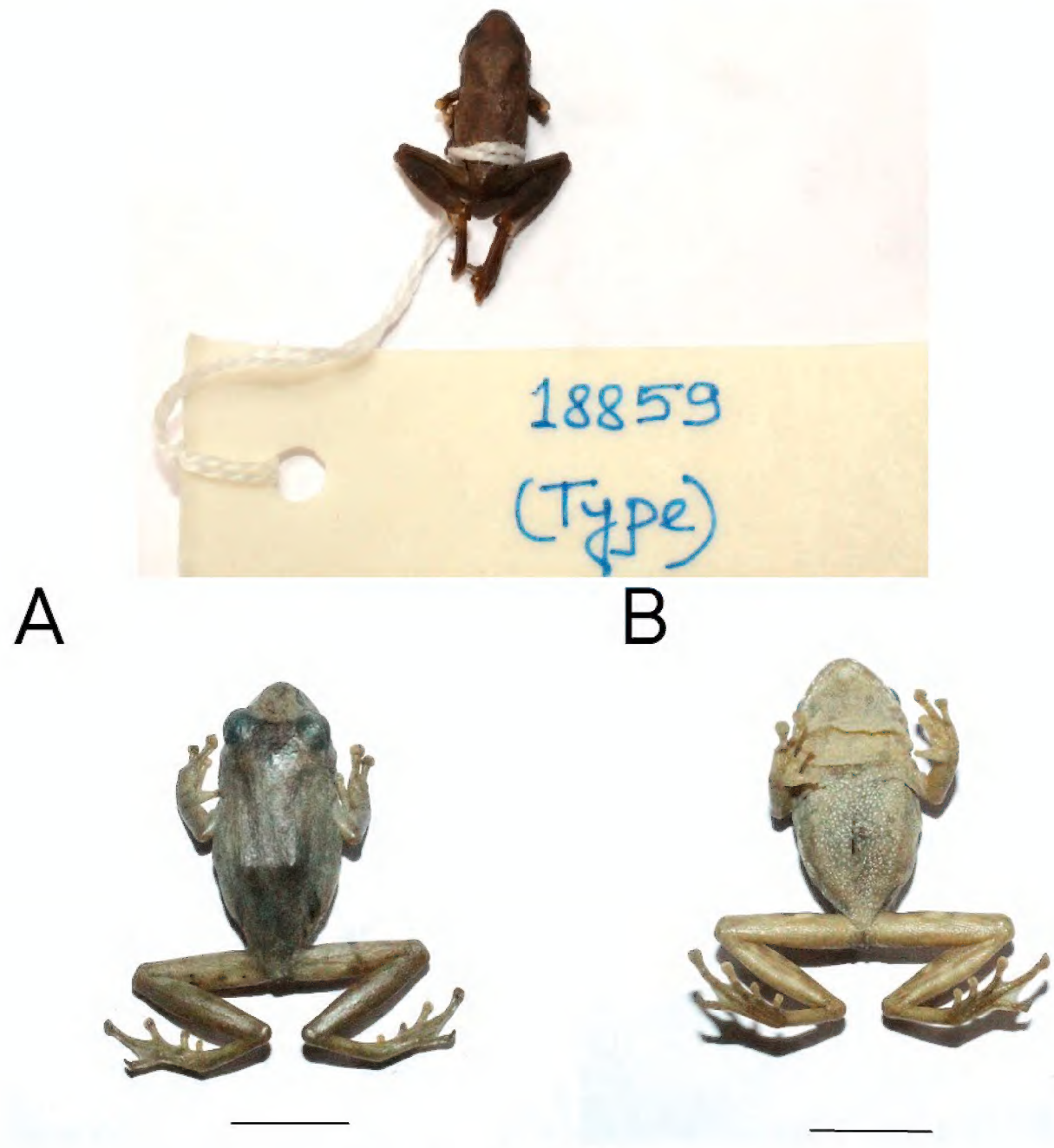

Figure 4. The holotype of *Ixalus kempiae* (ZSI 18859) - not to scale (above); SACON VA 806 in preservation (below). **A.** Dorsal view; and **B.** Ventral view. Scale bars: 10 mm.

Figure 5. *Raorchestes kempiae* (dorso-lateral view of SACON VA 806 on top and dorso-lateral view of an uncollected male, bottom) from Garo Hills in life.

Table 3. Morphometric measurements (in mm) of *R. kempiae*.

Voucher no:	Sex	SVL	AG	BW	HL	HW	HD	ED	EN	ES	TYD	ET	UEW	IO	IN	UAL	LAL	PAL	FEL	TBL	TRL	FOL
Holotype (ZSI 18859)	NA	16.3	6.02	6.14	5.22	5.76	3.14	2.44	1.7	2.04	0	0	1.4	1.7	1.4	2.42	2.82	2.46	6.7	7.92	5	U/N
SACON VA-806	Male	23.8	9.7	9.52	7.76	9.36	5.34	2.96	2.5	4.1	0	0	2.12	4.5	6.5	6.58	11.42	12.16	7.7	9.26	2.68	2.72
SACON VA-301	Male	21.9	7.94	9.82	6.42	8.58	4.3	3.24	1.88	3.52	0	0	1.88	3.8	4.9	5.78	9.9	10.86	6.5	9.2	2.3	2.92
SACON VA-302	Male	25	11.92	11.58	7.78	9.6	4.96	3.72	1.66	3.6	0	0	2.9	4.8	5.44	6.2	12.54	12.7	7.18	9.44	2.14	3.32
SACON VA-297	Male	25.2	13	11.66	8.14	9.56	5.98	4.16	1.92	3.86	0	0	2.6	3.94	5.26	6.12	12.2	13.12	7.4	10.26	2.24	3.32
SACON VA-299	Male	24.6	11.52	10.6	7.52	10.68	4.76	3.62	1.2	3.34	0	0	2.2	4.6	6.02	7.6	12.48	12.72	7.1	9.82	2.2	3.00

R. manipurensis, we do not address this in the current work and recommend that resolving this taxonomic uncertainty should be a priority for further study.

Comparisons. *Raorchestes kempiae* is genetically divergent (5.25–9.47% on the 16S rRNA gene) from congeners, with the least divergent species being Western Ghats endemic *R. ghatei*, with a divergence of 5.77%. From congeners in this region, it can be easily distinguished by: absence of an externally visible tympanum (vs. present in *R. garo*, *R. hekouensis*, *R. malipoensis*, *R. parvulus*, *R. dulongensis*, *R. hillisi*, *R. huanglianshan*); ventral aspect of the hind limb uniform creamy white (vs. dark gray in *R. rezakhani*); ventral surface mostly smooth with slight granulation (vs. granulated and well developed whitish tubercles in *R. hekouensis*); toe webbing I1-2II2-1III1-1IV1-2V in *R. kempiae* (vs. I1-1II1-1III3-3IV3-2.5V in *R. garo*, I 2–2 II 2–2 III 2–3 IV 3–2 V in *R. malipoensis*, II 1–2 III 1–2.5 IV 2.5–1 V in *R. menglaensis*, II 1–2 III 1–2.5 IV 2.5–1 V in *R. hillisi*, II 1–2 III 1–2–IV 2–1 V in *R. huanglianshan* and I2–2 II 1.75–2 III 1.5–3 IV 2.75–2 V in *R. rezakhani*); snout rounded in *R. kempiae* (vs. pointed in *R. annandalii* and short and truncate in *R. garo*).

Raorchestes asakgrensis Naveen, Chandramouli & Babu, sp. nov.

https://zoobank.org/3AC56A6A-DBAE-4F49-9B8C-D425E38E0B79

Material studied. ***Holotype*:** An adult female, SACON VA 805 (Fig. 6) from Eman Asakgre Community Reserve (25.36788°N, 90.54344°E, 174 m), Meghalaya, India, collected by RSN on August 15th, 2023.

***Paratypes*:** Three adult males, SACON VA 339, 340, and VA 343, from Eman Asakgre Community Reserve (25.36788°N, 90.54344°E, 174 m), Meghalaya, India, collected by RSN on August 15th, 2023.

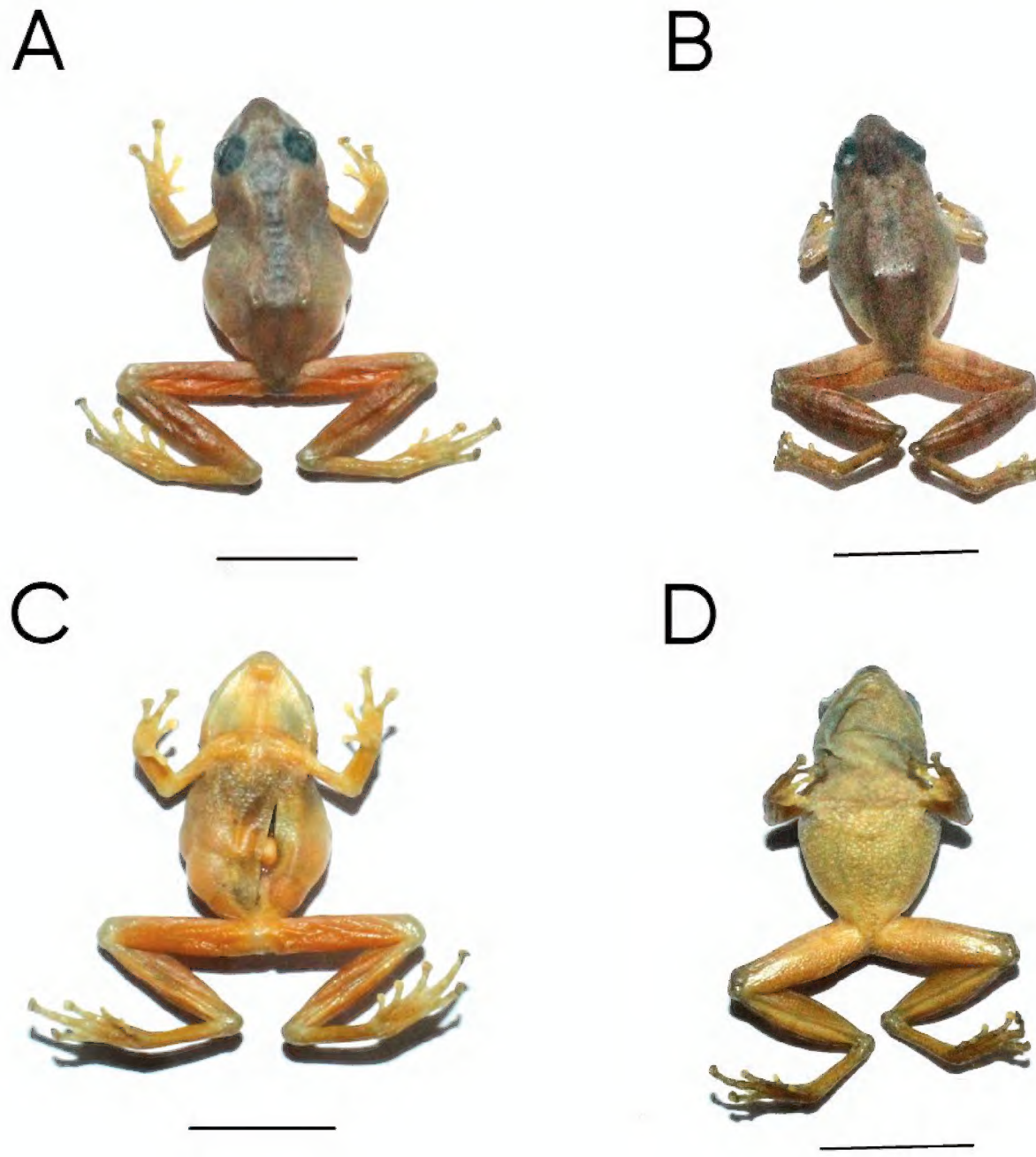

Figure 6. Adult female holotype (SACON VA 805) and adult male paratype (SACON VA 343) of *Raorchestes asakgrensis* sp. nov. in preservative, **A.** dorsal; **C.** ventral of holotype, and **B.** dorsal; **D.** ventral of paratype. Scale bars: 10 mm.

Diagnosis. *Raorchestes asakgrensis* sp. nov. is placed in the genus *Raorchestes* due to the combination of the following characters: small body size, vomerine teeth absent, single translucent external subgular vocal sac present, and tips of all fingers and toes expanded into discs with circum-marginal grooves (see Biju et al. 2010). The species can be distinguished from congeners in the Indo-China region by the following combination of characters: A small-sized (mean SVL 20.49 mm) arboreal species with an obtusely pointed snout; tympanum fairly visible with a visible supra-tympanic, relatively weakly developed; vomerine teeth absent; single semi-transparent gular vocal sac; tongue without papilla; ventral aspect of the hind limb uniform white as the venter; finger and toe discs well developed; toe webbing I1-2II2-2III2-1IV1-2V. Phylogenetically, *R. asakgrensis* forms a well-supported clade (BS: 100) consisting of two more Genbank sequences from 'India' (JX092712.1) and Nongkhyllem, Meghalaya (MN524578.1).

Description of the holotype. A small-sized *Raorchestes* (SVL 22.8 mm), dorsal and lateral skin smooth, venter granulated. Head wider than long (HL:HW 0.82); large (HL:SVL 0.28). A short snout (ED:ES 0.9), obtusely pointed in dorsal view. Canthus rostralis evident and rounded; loreal region concave. Trunk short (AG:SVL 0.43) and less gracile (AG:BW 0.95); eyes large (ED:HL 0.42); nostrils rounded, situated closer to the snout tip than to the eyes (EN:ES 0.53), directed laterally with no visible rim. Tympanum fairly visible, rounded in shape (TYD 1.92 mm); Supra-tympanic fold relatively weakly developed; Inter-orbital space broader than inter-narial space (IO:IN 1.14). Upper arms short (UAL:SVL 0.18), shorter than lower arms (UAL:LAL 0.79); palm shorter than the upper arms (UAL:PAL 0.75); relative finger lengths III>IV>II>I. Subarticular tubercles distinct in both palmar and plantar surfaces, rounded; Supernumerary tubercles present in the palm; no webbing between fingers; fingers with well-developed rounded discs. Thighs short, nearly half as long as the body (FEL:SVL 0.48), slightly shorter than the tibia (FEL:TBL 0.89). Foot slightly shorter than the thigh (FEL:FOL 1.12), toes, short with well-developed rounded discs and partial webbing, webbing formula I1-2II2-2III2-1IV1-2V. In life dorsum uniformly brown with a faint ")-(" mark; loreal yellowish brown; iris golden brown. Venter uniformly white, pale white eggs visible through ventral surface. Forearm and hindlimbs with dark brown bands (Fig. 7).

Variation. Measurement of the paratypes presented in Table 4. Variations noted during examination of preserved specimens and live individuals observed in the field. The single known female (Holotype VA 805) is larger (SVL 22.8 mm) than all the male specimens examined during this study (range 18.68–21.5 mm; mean SVL 19.72 mm). One of the male paratypes (VA 340) with a thin yellow line passing dorsally from the tip of the snout to the cloaca and extending through the thighs and shank (Fig. 7). Dorsal coloration pale to dark brown with or without a faint or dark hourglass pattern, ")(".

Comparisons. *Raorchestes asakgrensis* sp. nov. is genetically divergent (5.8–10.8%) from congeners, with the closest species being *R. shillongensis* with a divergence of 5.8%. On the phylogenetic tree, it clusters with a clade comprising *R. garo* and *R. shillongensis*, with a moderate node support (79). From species occurring in the Indo-China region, it can be distinguished by: having an obtusely pointed snout (vs. truncate and scarcely projecting in *R. garo*, rounded in *R. kempiae*, *R. menglaensis*, *R. hillisi*, *R. hekouensis*, *R. malipoensis*, *R. longchuanensis*, *R. dulongensis*, and *R. huanglianshan* and sharply projecting in *R. annandalii* and *R. yadongensis*), a fairly visible tympanum (vs. not externally visible in *R. kempiae*, *R. shillongensis*, *R. rezakhani*, *R. menglaensis*, and *R. parvulus*); and the presence of supernumerary tubercles on the palmar surface (vs. absent in *R. dulongensis*, *R. yadongensis*, and *R. hekouensis*). Ventral aspect of the hind limb uniformly creamy white in color (vs. dark orange in *R. garo* and *R. annandalii*, yellow with brown to black blotches in *R. kempiae*, and pale brown with white flecks in *R. parvulus*); toe webbing formula I 1-2 II 2-2 III 2-1 IV 1-2 V (vs. I 1-1 II 1-1 III 3-3 IV 3-2.5 V in *R. garo*, I1-2II2-1III1-1IV1-2V in *R. kempiae*, I 2–2 II 2–2 III 2–3 IV 3–2 V in *R. malipoensis*, II 1–2 III 1–2.5 IV 2.5–1 V in *R. menglaensis*, II 1–2 III 1–2.5 IV 2.5–1 V in *R. hillisi*, II 1–2 III 1–2 – IV 2–1 V in *R. huanglianshan*, I2–2II1.5–3.25III2–3.5IV3.25–2V in *R. parvulus* and I2–2 II 1.75–2 III 1.5–3 IV 2.75–2 V in *R. rezakhani*).

Remarks. The new species is clearly differentiated by a distinct set of morphological characters, particularly the presence of an externally visible tympanum and snout shape (see Fig. 7). Boruah et al. (2018) reported a *Raorchestes* sp. from regions north of the Khasi Hills, and it is likely that this could be *R. asakgrenesis*, as we also recorded this species from near Nongkhyllem Wildlife Sanctuary.

Natural history and distribution. The frogs were seen calling at dusk from bushes in and around the Eman Asakgre Community Reserve. A single amplecting pair was recorded at around 19:30 h perched on a bush 1.5 m above the ground during the pre-monsoon season following the first shower in May. The sequence generated during the current study also matches closely with a sequence from Nongkhyllem (MN524577.1), foothills of Khasi hills (about 150 km away from the type locality) in Meghalaya. In addition to this, during this study this species was also recorded from various locations across Garo hills (Sasatgre, Oragitok, and Dangkipara) and low-elevation regions of Khasi hills (Umling and Nongpoh). We calculated the extent of occurrence of this species with the current data from this study, and it was estimated to be 1,625 km^2 across an elevational range of 150 m asl to 950 m asl; however, further surveys are required to robustly estimate the distribution range of this species.

Etymology. The species is named after the type locality, Eman Asakgre Community Reserve, to honor the residents who greatly supported the surveys during which the type specimens were collected.

Figure 7. *Raorchestes asakgrensis* sp. nov. holotype, SACON VA 805, an adult female dorso-lateral view in life (above); paratype, SACON VA 340, an adult male dorso-lateral view in life (below).

Table 4. Morphometric measurements (in mm) of *R. asakgrensis* sp. nov.

Voucher no:	Sex	SVL	AG	BW	HL	HW	HD	ED	EN	ES	TYD	ET	UEW	IO	IN	UAL	LAL	PAL	FEL	TBL	TRL	FOL
SACON VA 805 Holotype	F	22.8	10.02	10.5	6.4	7.72	4.5	2.7	1.6	3	1.92	0.44	1.6	3.2	2.8	4.12	5.18	5.5	11.02	12.42	7.3	9.82
SACON VA 343	M	21.5	10.74	8.14	5.82	7.6	4.68	2.6	1.42	3.18	1.18	0.52	1.84	2.98	1.98	3.82	5.08	5.2	10.64	11.64	6.98	8.3
SACON VA 340	M	18.68	8.24	7.18	5.04	7.14	4.54	2.72	1.42	2.54	0.8	0.42	1.42	2.42	1.8	3.68	4.12	5	10	10.68	6.44	7.24
SACON VA 339	M	18.98	7.92	8.68	6.34	7.02	5.14	3.12	1.44	3.02	0.92	0.52	1.44	2.34	2.4	4.94	4.12	4.22	9.3	10.54	6.6	7.24

Discussion

To date, three species of bush frogs have been discovered and described from the Garo and Khasi hills: *Ixalus garo* and *I. kempiae* by Boulenger (1919), and *Philautus shillongensis* by Pillai and Chanda (1973). Boruah et al. (2018) redescribed *Raorchestes shillongensis* and clarified that its distribution is restricted to the higher elevations of the Shillong Plateau in the Khasi Hills. However, *Ixalus garo* and *I. kempiae*, originally described over a century ago, based on only a single subadult type specimen each, have remained poorly known since then, to the extent that even their generic placement has remained unclear (see Frost 2024). Our study, based on the mitochondrial 16S rRNA gene, shows that they belong to the genus *Raorchestes*. Boulenger (1919) described *Ixalus garo* based on a single specimen from above Tura in the Garo Hills that was characterized by a distinct tympanum that was 1/3rd the diameter of the eye, fingers, and toes with discs as large as the tympanum, toes webbed at the base, grayish with an hourglass pattern on the back, and a grayish belly dotted with white. The specimens allocated to *R. garo* described above agree with the description and exhibit no morphological differences from the holotype of the species; hence, we identified them as *Raorchestes garo*. Similarly, for *Ixalus kempiae*, Boulenger (1919) characterized it based on a rounded snout, hidden tympanum, large discs on fingers and toes, toes webbed at the base, grayish above with small black spots, a black cross-band between the eyes, a ")(" shaped marking on the back, and a whitish belly spotted and marbled with brown. Our newly collected material from the near-type locality not only matches the description of *Ixalus kempiae* by Boulenger (1919) but

also matches the description of *Raorchestes cangyuanensis* by Wu et al. (2021). Therefore, we place the name *Raorchestes cangyuanensis* under the subjective junior synonymy of *Raorchestes kempiae* owing to its genetic congruence and morphological similarity with our new sample (see Tables 1, 3). In addition to this, the discovery of *Raorchestes asakgrensis* sp. nov. from a low elevation site near the foothills of the Garo Hills of Meghalaya, which is differentiated from all other sympatric species by a unique set of morphological characters as well as molecular differences, highlights the importance of integrative taxonomy, which combines multiple lines of evidence to accurately classify and recognize species. This study now confirms the presence of four species of bush frogs in the genus *Raorchestes* from the Garo and Khasi Hills of Meghalaya. In addition to these, Mathew and Sen (2010) reported the presence of *Raorchestes annandalii* (Boulenger, 1906) from Meghalaya. However, this poorly known species, originally described from Kurseong, Darjeeling, is separated from Meghalaya by the Brahmaputra River (see. Fig. 8), which serves as a barrier for many species in this region (Chaitanya et al. 2024). Thus, further studies are needed to confirm the presence of this species in Meghalaya.

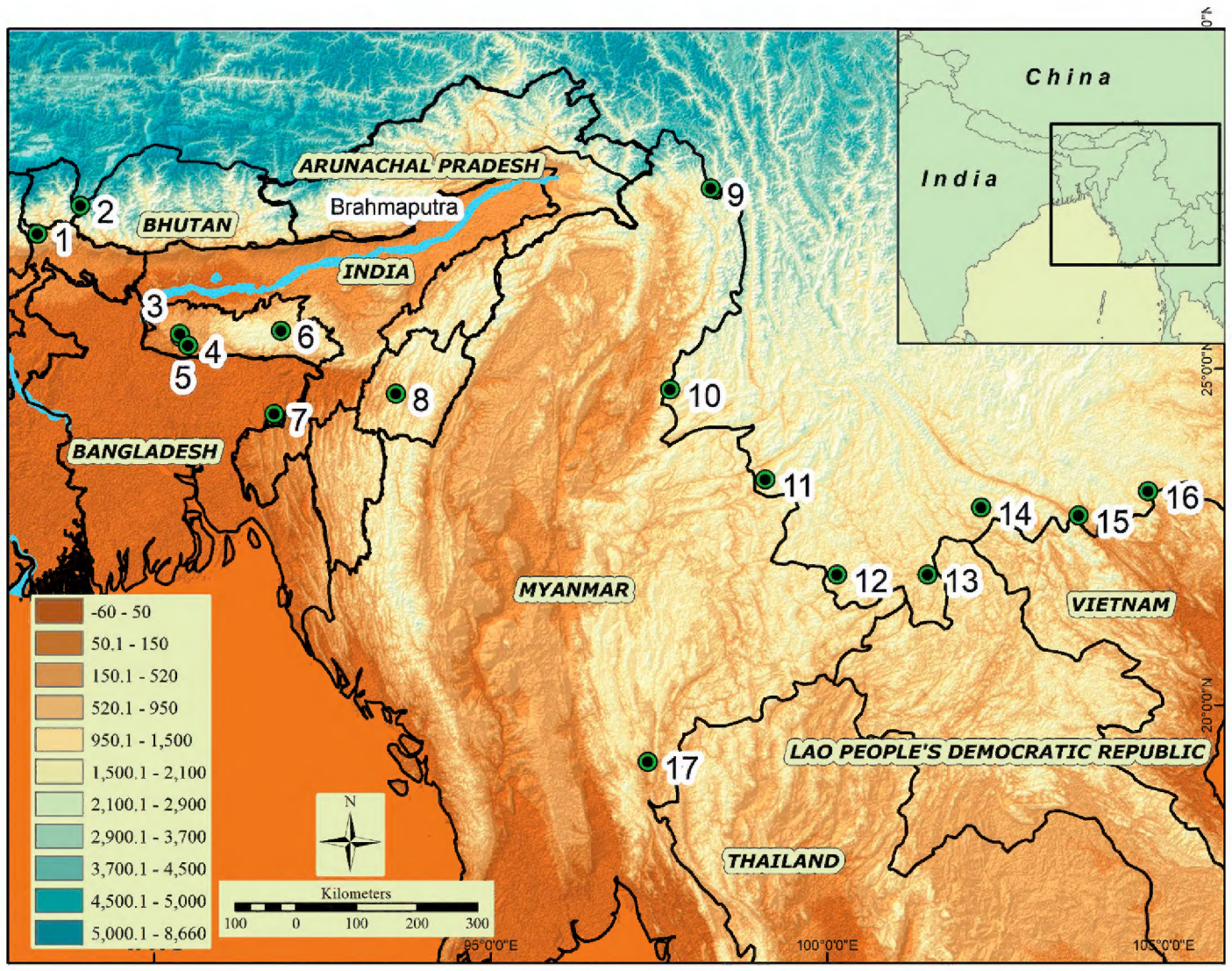

Figure 8. Map showing the type localities of *Raorchestes* species known from the Indo-China region, including 1. *R. annandalii*, 2. *R. yadongensis*, 3. *R. garo*, 4. *R. asakgrensis* sp. nov., 5. *R. kempiae*, 6. *R. shillongensis*, 7. *R. rezakhani*, 8. *R. manipurensis*, 9. *R. dulongensis*, 10. *R. longchuanensis*, 11. *R. "cangyuanensis"*, 12. *R. hillisi*, 13. *R. menglaensis*, 14. *R. huanglianshan*, 15. *R. hekouensis*, 16. *R. malipoensis*, and 17. *R. parvulus*.

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Appendix 1

Table A1. Genbank accession numbers of sequences used in this study.

Accession number and species	Reference
PQ512828 *Raorchestes asakgrensis* sp. nov.	This study
PQ512827 *Raorchestes kempiae* comb. nov.	This study
PQ585812 *Raorchestes garo* comb. nov.	This study
MN524577.1 *Raorchestes* sp.	Laskar et al. 2019; unpublished
JX092712.1 *Raorchestes* sp.	Vijayakumar et al. 2014
MG980283.1 *Raorchestes shillongensis*	Boruah et al. 2018; unpublished
MN475871.1 *Raorchestes longchuanensis*	Wu et al. 2019
MW938630.1 *Raorchestes longchuanensis*	Lalremsanga et al. 2021; unpublished
MN193413.1 *Raorchestes longchuanensis*	Al-Razi et al. 2020
MN072374.1 *Raorchestes rezakhani*	Al-Razi et al. 2020
KF366385.1 *Raorchestes ghatei*	Padhye et al. 2013
MN475869.1 *Raorchestes gryllus*	Wu et al. 2019
JX092687.1 *Raorchestes* sp.	Vijayakumar et al. 2014
MT488411.1 *Raorchestes hillisi*	Jiang et al. 2020
MW019900.1 *Raorchestes menglaensis*	Xu et al. 2021
MW537816.1 *Raorchestes dulongensis*	Wu et al. 2021
KP137388.1 *Raorchestes tuberohumerus*	Padhye et al. 2014; unpublished
MW019901.1 *Raorchestes parvulus*	Wu et al. 2020
MT488414.1 *Raorchestes huanglianshan*	Jiang et al. 2020
MG980285.1 *Raorchestes* sp.	Boruah et al. 2018; unpublished
MK188865.1 *Raorchestes sanctisilvaticus*	Warekar et al. 2018; unpublished
MN475866.1 *Raorchestes cangyuanensis*	Wu et al. 2019
MT983169.1 *Raorchestes annandalii*	Khatiwada 2020
MH789426.1 *Pseudophilautus schmarda*	Meegaskumbura et al. 2018
KP939071.1 *Pseudophilautus kani*	Sureshkumar and George 2015; unpublished
MW356660.1 *Philautus nepenthophilus*	Etter et al. 2021
KT445970.1 *Philautus nephophilus*	Dehling et al. 2016
KU170003.1 *Nasutixalus jerdonii*	Biju et al. 2016